THE

Indian Tea Association.

SCIENTIFIC DEPARTMENT

QUARTERLY JOURNAL.

PART I.

1928.

Calcutta:
PRINTED AT THE CATHOLIC ORPHAN PRESS,
3 & 4, Portuguese Church Street.

1928.

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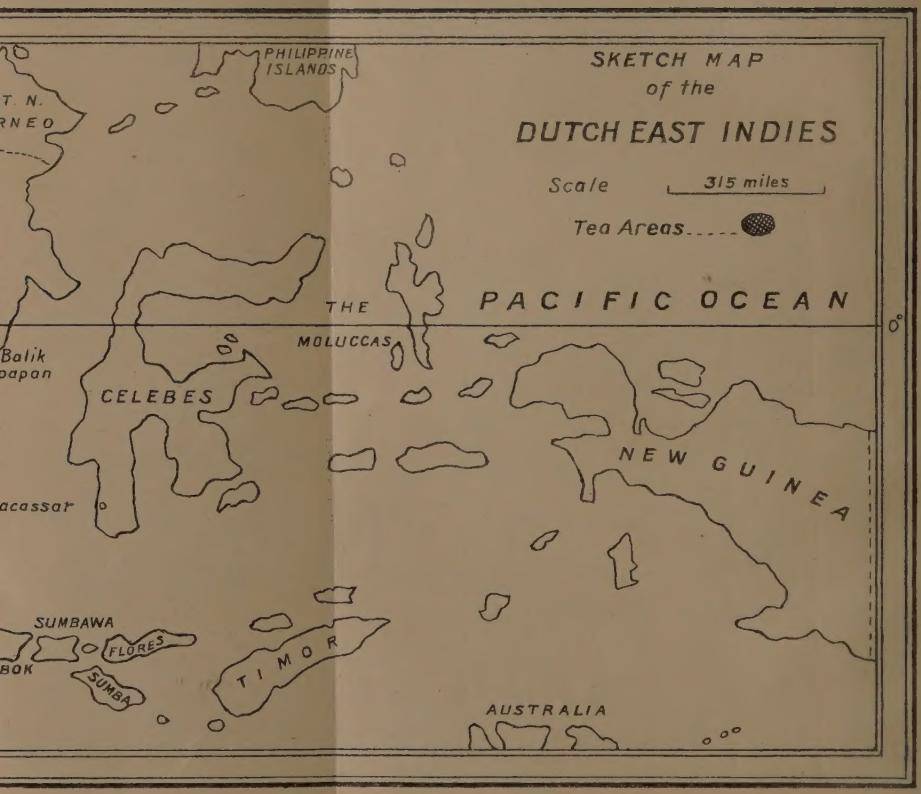
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TEA IN JAVA.

BY

C. R. HARLER.

The account of tea in Java which follows, does not pretend to be a comprehensive description of the industry in that country. It is largely an elaboration of notes made during a visit to the tea districts of Java, referring mainly to differences between methods in that country and North-East India.

Whilst in Java, I was shown every courtesy and kindness. Mr. Lagmans of Geo. Wehry and Co., showed me something of the business side of the tea industry in Batavia and introduced me to the Tea Expert Bureau there. Dr. Bernard, chief of the Tea Experimental Station at Buitenzorg, arranged an itinerary on my behalf, and thus gave me the opportunity of seeing typical estates in the various tea areas. At Buitenzorg I met the scientists engaged on tea problems and discussed subjects of common interest with them. Messrs. Garretsen and Keuchenius, of the Theeproefstation staff, took me to estates round Buitenzorg, Soekaboemi, Bandeong and the Pengalengen. I was also shown the tea seed gardens and selection work being carried out at Tjinjiroean on the Pengalengan plateau.

I take this opportunity to thank these gentlemen for their kindness, and also to thank the various estate managers for their hospitality, and the trouble they took in showing me their estates and factories.

I am aware of the danger of generalising from impressions, and took care to verify most of my statements with members of the Experimental Station. It is thus possible that many of the statements made in this account may be the ideals suggested by the scientists at Buitenzorg, to which the actual practices in Java only approximate. I know from my own experience that in speaking to strangers about methods employed on tea gardens in Assam, I am apt, unconsciously, to describe things as they should be rather than as they actually are.

The Dutch East Indies.

The Dutch East Indies is the collective name for a series of islands and island groups stretching from Further India to Australia. These islands are situated between 75° and 141° east longitude, and between 6° north and 11° south of the Equator. The Dutch name for this area is Nederlandsh-Indië. It is difficult, at first, to realise the extent of this island empire. The maximum length from west to east, *i.e.*, from Sabang, in Sumatra, to Humboldt Bay, in New Guinea, is about 3,125 miles. From north to south the maximum distance is is about 1,250 miles.

The Netherlands Indies comprise the large islands of Java and Sumatra, the greater part of Borneo, Celebes, the western part of New Guinea and innumerable small islands. The island of Timor belongs partly to Portugal. The total area under Dutch control is 733,681 square miles and this is inhabited by over 51 million souls (census, January 1926). The table below gives a survey of the area and population of the four largest islands and of the remainder of the area, which is largely made up of Dutch New Guinea.

	Sq. miles.	Population.
Java ...	... 50,762	36,403,833
Sumatra ...	... 162,268	6,218,724
Borneo (Dutch)	... 213,589	1,757,963
Celebes ...	... 71,763	3,314,344
Rest of archipelago	... 235,299	3,319,014
Total, Dutch East Indies	733,681	51,013,878

The Dutch East Indies are about fifty-four times as big as Holland. A further idea of the size of this empire is given by comparing it with the total area of the British Isles, which is 121,000 square miles.

Although Java is, as yet, the only well developed island, Sumatra is progressing rapidly and, with the other islands, will

in time go to make this area one of the richest in the world. All the islands of any size are connected by regular Dutch steamer services which run with a remarkable punctuality. Dutch lines also run from Java to Europe, Australia and the Far East.

Up to now the economic development of the Dutch Indies has been bound up with agricultural products. Native agriculture has for its chief object the supply of foodstuffs to the inhabitants, whilst estate agriculture works almost exclusively for export. The chief native crop is rice, followed by maize, then tapioca, sweet potatoes, pea nuts and soya beans. One of the most important estate products is rubber, of which about a million and a quarter acres are planted, partly in Java and partly in the other islands. The total output of this commodity is more than 35 per cent. of the world's production. Sugar, coffee, tea and tobacco are also large industries. Java possesses almost the monopoly of cinchona and more than 90 per cent. of this product placed in the market comes from the island.

Politically the Netherlands Indies forms part of the Kingdom of the Nederlands and the Dutch legislation is the highest lawful power. Practically speaking, however, only when laws concerning the economic situation are in question is the Home influence exerted. With this exception, the colony enjoys administrative self-government on a large scale. The supreme power is in the hands of the Queen of Holland who rules in accordance with Government regulations. The Governor-General rules in name of the Queen, and he is assisted both in his legislative and executive power by an official advisory body, the Council of the Netherlands Indies.

In 1918, a representative body known as the " Volksraad " (People's Council) was formed, members of which are partly elected, and partly appointed by the Governor-General. The latter can consult this Council on all matters, but is obliged to do so on such matters as budget, colonial loans and military obliga-

tions of the residents. In 1925 the competence of the Volksraad, in regard to legislation and budget, was considerably extended.

Administratively the territory is divided into residencies, each controlled by a resident with subordinates under him. In the villages, the natives are largely controlled by their own chiefs, the Dutch civil service only supervising the native government.

Java is by far the most important island in the archipelago. Its length, from east to west, is 665 miles and its breadth varies from 33 to 120 miles. In size, it is slightly smaller than England and Wales and in population it is also slghtly less. The island lies entirely between the 6th. and 8th. degrees of south latitude, and is hence situated about as far south as Ceylon is north of the Line.

The flora of Java is tropical and resembles very much that of the wet part of Ceylon. In the mountain region a subtropical vegetation occurs.

The subterranean soil is ancient rock broken by many volcanoes, for Java is situated on or about one of the great fissures in the earth's crust, and the volcanoes form one of the outstanding features of the island. There are about fifty volcanoes in Java and the upper layers of the soil are, for the greater part, composed of volcanic material, generally of recent geological origin. Buitenzorg is situated between two magnificent cones, Salak and Gedek, both well over 6,000 feet high, and on the flanks of these two volcanoes many estates are situated.

The ascent of a volcano is an interesting experience. Round the base of the cone the vegetation is tropical and dense but towards the top it becomes stunted and small leaved. Finally all vegetation ceases and the track leads across pumice and scoria to the crater's edge. The atmosphere along the path to the crater is charged with sulphurous fumes.

The large craters present an inspiring sight, not only on account of their size and depth, but also because of the constant rumble and roar of the troubled, boiling mud pools deep down in the centre, which emit gusts of sulphurous steam.

In Java there is a volcanic service, the function of which is to observe the nature of the activity of the volcanoes. Twice daily temperatures in the craters are taken, and it is possible from these, and other observations, to predict eruptions.

Batavia, the capital of Java, has a population of 354,737 of whom 37,053 are Europeans. The other ports are Sourabaya with a population of 248,961 and Samarang with 150,952 inhabitants. All these three cities are on the low northern coast of the island. Soerakarta and Djokjakarta are large inland towns and centres of Javanese life and custom. Bandeong is a modern town in the centre of the island, situated at the base of the Pengalengan plateau at an altitude of about 2,000 feet. Its position and climate are extremely pleasant, and this spot is a favourite one for Dutch people who retire and settle in the island.

The communications in Java are excellent. Railways and steam tramways run all over the island. From Priok, the port of Batavia, to Weltevreden, the modern city, a distance of about seven miles, the line is electrified, and the electrification is being extended to Buitenzorg, 38 miles inland. Such an extensive system of excellent metalled roads has been constructed that there is practically no place of any importance which cannot be reached by motor, over a good road. Canals are used in the lowlands and, largely on this account, the country is frequently likened to Holland.

A complete telephone system is in use, and there are several wireless stations in Java, and others scattered throughout the Dutch islands.

The native inhabitants of Java are of the Malay stock and are Mongolians. Chinese and Arabs are the most numerous of the foreigners present, although the Europeans total 176,806. The great majority of the native population are Mohammedans which faith was first introduced by the Arabs in the fifteenth century. Prior to this, the Hindu influence had been great, as is evidenced by the magnificent temple at Borobudur

and other remains found in various places, relics of a former Hindu-Javanese empire.

The Tea Industry in Java.

The introduction of tea into Java and the subsequent development of the industry was along lines parallel to those followed by the industry in India. In about 1690, Camphuys, the Governor-General of Java, planted the first tea in that country purely as a matter of interest, just as Captain Kyd did in India, in about 1780. In 1728, the Dutch East India Company seriously considered the planting of tea in Java as the British company did in 1788. Neither of these schemes were carried through and it was not until 1825 in Java and 1835 in India that tea, as an industry, may be said to have started.

In 1825, the Dutch Government ordered tea seed from Japan through the renowned expert on things Japanese, von Siebold, and during the following years increasing quantities of both China and Japan seed were imported into Java.

In British India, tea plants were brought from China in 1835 and planted at Kumaon. This step was activated by the fact that the monopoly of the tea trade with China, previously held by the British East India Company, expired in that year. Although Bruce had discovered tea growing wild in Assam in 1823 it was not until a scientific deputation had visited that country in 1835-36 that the tea project moved thence.

The industry in Java did not advance so steadily as in North East India, for it is only comparatively recently (from about 1900) that Java teas have become an important factor in the world's tea market.

In 1832 the Dutch Government, realising the possibility of tea as an industry, brought expert tea makers from China to work in Java. The results were not successful. In 1838 an establishment for the finishing of tea was established in Batavia, presumably in accordance with Chinese methods. Owing, however, to difficulties of transport, the final treatment was often not given until several months after the preliminary manufac-

ture, and this naturally caused serious deterioration in the quality of the product. The result was that the tea was sold at a loss which, between 1835 and 1860, became so serious, that the Government abandoned its direct connection with the industry as existing contracts expired.

In 1865 several estates were rented to private individuals in the Preangers and others were opened out. The quality of the tea, however, was still inferior and could not compete with that of British India. In about 1878, hand manufacture was replaced by machinery and considerable improvement in quality was thereby effected.

Assam seed was first imported in 1872 although the first real success with this seed was not obtained till 1878. It is reported that Assam seed was imported from Ceylon to Java as early as 1877, but, as the plants proved scarcely different from "Java" or China tea, the experiment was given up. During the tea rush in the 'eighties, more Ceylon seed was imported with no more encouraging results than before. The Assam plant has been so successful in Java that it has now become the standard type in the island.

In 1882, the society known as the Soekaboemi Agricultural Syndicate was formed with the object of looking after the interests of the tea and allied industries in Java. During the 'nineties the Government took a great interest in tea and deputations visited India and Ceylon, which led to changes in Java methods. In 1902, a Tea Experimental Station was established by Government.

The growth of the industry is illustrated by the exports during the last quarter of a century.

1901	export	16,750,000	lbs.
1905	,,	25,500,000	,,
1910	,,	40,600,000	,,
1915	,,	101,600,000	,,
1920	,,	93,700,000	,,
1925	,,	94,800,000	,,

The break from the steady increase in 1920 was due to the post-war slump in tea prices, following on a period of over production. Exports are now again steadily increasing and at a much faster rate than those from either India or Ceylon. In 1925, Java and Sumatra exported over 111 million pounds, in 1926, over 136 million pounds and in 1927, over 145 million pounds.

At the end of 1925 there were 194,439 acres under tea in bearing in Java, and 26,621 acres in Sumatra, although in the latter country about 32,000 acres were planted. Of the 285 tea estates in the Dutch Indies, 260 are in Java and the remaining 25 in Sumatra. Although there is practically no more land available for tea cultivation in Java, extensive tracts in Sumatra have been found suitable for tea. In 1911, only 500 acres were planted in this latter island, but the success was such a signal one that the area has steadily increased. Most of the Sumatra estates are on the east coast, but areas on the west coast are now being fast opened out. The annual tea output of Sumatra is at present about 18 million pounds, and a great increase is to be expected in the next few years.

In 1926 the yield per acre was about 700 lbs. tea in Java and 650 lbs. in Sumatra, against about 600 lbs. in North-East India.

The position of the tea crop from the Dutch Indies in the world market may be gauged from the export figures shown by the principal tea countries during 1926.

British India	export	337	million	lbs.
Ceylon	,,	207	,,	,,
Java	,,	118	,,	,,
Sumatra	,,	18	,,	,,
China	,,	111 (?)	,,	,,
Japan	,,	23	,,	,,
Formosa	,,	22	,,	,,

Regarding the price of Java teas, it is difficult to get a direct comparison with tea from other countries, since only part of the

Java crop, and that probably, on the whole, the poorer part, is sold in London. Many estates sell their better grades in Batavia and Amsterdam. The table below shows the average prices for the 1926 crop obtained in the London sales.

	s. *d.*
North India ...	1/5.68
South India ...	1/5.62
Ceylon ...	1/8.09
Sumatra ...	1/4.56
Java ...	1/0.83
Nyassa ...	1/1.24

The individual districts in North-East India for the same season made the following averages :—

	s. *d.*
Assam ...	1/6.38
Darjeeling ...	1/9.24
Dooars ...	1/4.38
Cachar and Sylhet ...	1/2.54

The London prices flatter somewhat the quality of Indian tea as a whole for, generally speaking, the better teas are sold at Home, and a great proportion of the poorer teas are sold in Calcutta.

However, making allowances for these facts, Java teas are undoubtedly inferior to Indian teas, although not to the degree shown by the London values. Many reasons for this inferiority have been given. One is the fact that there are about 60,000 acres of *kampong* (Malay, village) and native tea plantations. These areas are generally put out without a factory and the leaf is sold to gardens with factories. *Kampong-blad* (village leaf) is bought, usually, when the market is strong. *Kampong* tea is generally poorly cultivated and roughly plucked, although some of it, contiguous with European-owned estates, is very good, well-tended tea. The price paid for *kampong-blad* varies and and may be as much as 10 cents per ½ kilo (Rs. 9 per maund).

Another factor tending to lower the average price of Java tea is the sale of a rough grade, known as Bohea. This is only a small proportion, less than 5 per cent. perhaps, but it brings a very small price and lowers the average.

It is estimated that about 6½ million pounds of tea are consumed annually in Java. Garden labourers drink mostly Bohea. Of the tea exported, about 95 per cent. is shipped from Priok, the port of Batavia. The tea is exported mainly to Great Britain, Australia, Holland and the United States. Below is shown the distribution in 1925 of both Java and Sumatra teas.

	Java tea.	Sumatra tea.
Great Britain ...	39,475,000 lbs.	4,745,000 lbs.
Australia	32,968,000 ,,	3,067,000 ,,
Holland ...	19,650,000 ,,	5,381,000 ,,
United States ...	6,187,000 ,,	1,054,000 ,,

In 1905 it was decided to make a determined effort to improve the quality of Java tea and to this end a committee of leading planters, directors of planting companies and others interested in the tea industry suggested the formation of a Tea Expert Bureau. In 1906 an Englishman was employed to help the planters to make the best of their tea. The expert had an office first at Soekaboemi and, later, at Bandeong from which towns he reported on tea samples and visited gardens. There is no tea market in Batavia comparable with those in London, Calcutta or Columbo, but European buying firms have established themselves there and buy much tea by private contract. However, owing to the sellers having insufficient knowledge of the commodity and being out of touch with European markets, these contracts were not always, in the past, to the best advantage of the producer. Accordingly, in 1910 the Vereeniging "Thee-Expert-Bureau" took on its present form and moved to Batavia. The expert is British.

Only Dutch firms belong to the Bureau, for British agencies have their own tea tasters. At present 165 estates in Java and Sumatra are served by the Bureau, these including Arab and Chinese owned concerns.

Most of the Java tea is sold forward on the f. a. q. basis and it is the duty of the expert to see that the quality keeps up to the mark and to report any change of grade or shortcoming in the tea. In case of a dispute, the expert can act as arbitrator with two others.

The Bureau costs 60 to 70,000 guilders (£5,000 to £5,833) per annum, this sum being raised partly by a contribution of 10 cents (2*d*.) per 100 kilos (220 lbs.) of tea made, of a charge of 25 cents (5*d*.) per sample tasted, and of an annual charge of 50 guilders (£4-3-4) for circulars on prices, reviews, etc. From the sum raised, £1,000 is set aside for propaganda, which is used in advertising in American papers and journals.

The tea gardens of Java are run by agency houses much in the manner as in India. The managers and assistants on the estates are practically all Dutch. The salaries paid to tea planters are about the same as in North-East India, but Home leave is given less frequently. Commissions are higher than those usually given in North-East India.

The labour on Java tea estates is obtained locally, although in Sumatra it is recruited, on contract, from Java. In Java there is somewhat under one cooly an acre on the estate, but this figure varies widely. The labour is paid a rather higher wage than in North-East India, although the difference in cost of living may or may not account for this apparent extra remuneration. The cooly lines are well built and, on the whole, the standard of living is much higher in Java than in India.

The Tea Experimental Station.

The earliest scientific work on the subject of tea in Java was done by van Romburgh, Lohmann and Nanninga from the early 'nineties onwards, contemporaneously with that of M. Kelway Bamber in Assam and Ceylon. This work was carried out in the laboratories at Buitenzorg, connected with the famous Botanical Gardens.

In 1902 the Theeproefstation (Tea Experimental Station) was founded, with Nanninga as the first Director. In 1907,

Dr. Bernard, formerly of the Botanical Gardens, took over the Directorship and he still holds this post. The present staff consists, in addition to the Director, of two chemists, one botanist, one mycologist, one entomologist and three agriculturists.

The annual cost of the Tea Station is about 1,50,000 guilders (£12,500). A fine new stone building consisting of laboratories, offices, library, etc., comprising about 25 rooms, large and small, has just been erected some distance from the old laboratories at a cost of about 1,50,000 guilders.

In 1926 several associations were amalgamated and a central association consisting of a General Agricultural Syndicate for rubber, tea, coffee, cocoa and cinchona was formed. The money for scientific work will be raised by a cess of 2 guilders 20 cts. per hectare (about Re. 1-2 per acre). Under the previous system the money for the Tea Experimental Station was raised by a cess of about 20 cents (9 annas) per 100 kilos (220 lbs.) of tea produced. The cost of the Scientific Department at Tocklai works out at less than 8 annas per acre, owing to the fact that the annual expenditure, which is at present about £18,000, is borne by a much larger industry in India than in the Dutch Indies.

There was no tea for experimental purposes on the old Theeproefstation, but experiments were made on Pasir Soerronge, a garden some miles away. At the new station about 8 acres will be planted with tea and the nurseries are already put out (April, 1926). It is expected to have a larger area for planting eventually. At Buitenzorg, about 30 acres of land are devoted to green crops. This area is very fine and is managed by the Theeproefstation, although in 1928 it reverts to the Government Agricultural Department. There are many isolated areas in the jungle mostly at Tjinjiroean, on the Pengalengan Plateau, devoted to the work on tea selection.

The Theeproefstation published a quarterly journal, "De Thee"—which reached its seventh year, and also "Mededeeling-

en" or Reports on subjects concerning tea, as occasion arose. Between 1909 and the present, over eighty of these reports had been issued. Previous to 1907 the work on tea appeared in the journals of the Botanical Garden at Buitenzorg and in the Agricultural Reports. The scientists at the Theeproefstation publish many of their purely scientific works in European journals.

Since the formation of the General Agricultural Syndicate in 1926, mentioned above, the two series, "De Thee" and the "Mededeelingen van het Thee-proefstation," will be published in the "Archief voor de Thee-Culture."

Tea Selection.

The work on tea selection was first started in Java in 1910 by Dr. Ch. Bernard, Director of the Experimental Station, in a small garden set up at the Government Cinchona plantation. Other gardens were put out in the jungle on the Pengalengen Plateau and, as the work of type selecting grew, Dr. C. S. Cohen Stuart took over in 1913, and began to study the principles of tea selection and problems connected with propagation.

The peculiar interest in tea varieties which we have in Assam must be an excuse for the somewhat lengthy discussion on selection which follows.

When the East India Company decided to bring tea from China in order to grow it in India, and whilst C. G. Gordon was actually on his way from China in 1834, the report came through that tea had been discovered growing wild in Assam. Bruce had originally, in 1923, found tea near Sibsagar.

The first plants from China was put out at Kumaon and Dehra Dun, but since tea had been found indigenous in Assam, China plants were also out in that province. The commission of botanists consisting of Wallich, Griffith and McClelland which was sent to Assam in 1835-36 found tea growing wild in many places including Kutchu, Negrigram, Nadua, Tingri, Gabru-Purbat and Borhat, besides in the hills between Assam and Burma and at Bhamo on the Irrawaddy. It was concluded how-

ever that the Assam tea was a cultural variety of the China bush, which had reverted by growing in a wild state. The importation of China tea was therefore not considered harmful to the indigenous plant but was, indeed, considered desirable. This erroneous conclusion did much to introduce confusion into the tea strains of Assam which makes selection at present so very difficult.

When Cohen Stuart came to the problem, one of the aspects considered was that of the probable original home of the tea plant (1). A hypothesis has been put forward that, since the original tea areas are situated along several large rivers, the Yang-tse-Kiang, the Hsi-Kiang, the Song-Koi or Red River, the Mekong, the Salween, the Irrawaddy and the Brahmaputra, and since these rivers or their tributaries spring from the complex mountain system, conveniently termed the Ante-Tibetan range, to the east of Tibet, these mountains represent the original distribution centre of the tea plant and it allies. This hypothesis is refuted by Cohen Stuart and it is suggested that the China plant arose independently of the large leaved varieties and developed amidst the other *Camellias* and *Theas* growing in China, to which it shows a much closer resemblance than to western tea forms. China proper has a flora which is much more its own than is the widely distributed flora of Indo-China, Burma and Assam. Thus there is a large leaved India tea plant in Manipur and a large leaved China tea in Yunnan but no large leaved tea plant in China proper.

Having decided that the large leaved varieties of tea may have spread from the Ante-Tibetan range, Cohen Stuart goes on to study the transportation of the tea plant by man. Tea plants have been found near the important caravan roads between China and India. The transportation and hybridisation was generally east in Sy-Chuan, south in Yunnan and west in Burma. The

(1) "A Basis for Tea Selection" by C. S. Cohen Stuart, *Bulletin du Jardin Botanique de Buitenzorg*, Vol. I, fasc. 4, written in English, contains a full accountt of the botanical aspect of tea selection and a discussion on the geographical distribution of the tea plant.

typical Chinese plant has suffered less blending than the other varieties and has remained comparatively true-bred. The tea in the Shan States of Burma and Siam is the most hybridised. Assam indigenous tea has also been subject to changes from without. On the other hand it seems that Manipur, Cachar and Lushai tea, which differ so much from the other large leaved varieties, has been preserved from the taint arising from migration.

The confusion regarding the systematic botany of tea has been largely cleared up by Cohen Stuart. Linnaeus in his Species Plantarum (1753) formed two genera, *Camellia* and *Thea* and, at that time, two species of Camellia, *viz.*, *japonica* and *sasanqua*, were known, and one of *Thea*, *viz.*, *sinensis*, the tea plant. In 1762 the two varieties *Thea viridis*, the plant giving rise to green tea, and *Thea bohea*, that giving rise to black tea, were distinguished and the term *sinensis* was dropped. Later it was shown that both green and black tea were made from the same plant, which was then called *Thea bohea*. Confusion started from this time and increased as each botanist worked on the problem. Sir George Watt, the most notable botanist in connection with tea during the latter part of the nineteenth century, distinguished two varieties proper, *viz.*, *viridis* Watt (large leaved) and *lasiocalyx* Watt (small leaved). From these two, other varieties, *stricta*, *bohea* and Ceylon hybrid were considered to be derived by hybridization.

Later botanists have decided that two separate genera for *Camellia* and *Thea* species are no longer necessary and the combined genus is known as *Thea* since this name was the first mentioned by Linnaeus. Only one tea species, *Thea sinensis* (L.) Seem, is now recognised. The designation is somewhat unfortunate from the geographical viewpoint since it suggests China tea.

There exists, however, at least two morphological groups of tea plants, one of which is indigenous to China, the other to India, whilst there is, according to Cohen Stuart, not the small-

est evidence supporting the idea of any direct genetical or genealogical affinity connecting them.

To a great extent it is a question of convenience whether we speak of species of varieties, and the question ought not to be invested with undue importance. Within the species Cohen Stuart recognises four main groups.

Group I, China, variety *bohea*. Small leaves, 1½—2½ inches long, leaf stiff, leathery, usually deeply coloured with 6 to 8 pairs of veins which are not very prominent; leaves usually without a definite apex. This group occurs in East and South-East China and Japan.

Group II, variety *macrophylla* v. Siebold. Large leaves, up to 5½ inches long. Trees up to 16 feet high. Number of veins about 8 or 9; no leaf apex. Occurs in Hupeh, Sy-chuan and Yunnan.

Group III, Shan form, perhaps related to "Assam" tea. Large leaf, up to 6½ inches long. Trees 15-30 feet high. Leaf light coloured with about 10 pairs of veins and continuous apex. Occurs in Tongking, Laos, Upper Siam, Upper Burma (collectively known as 'Shan' lands), possibly also Assam.

Group IV, variety *assamica*. Very large leaves, 8-12 inches and even up to 14 inches in length. Trees up to 60 feet high. Leaves comparatively thin and flaccid, moderately dark green, with 12 to 15 pairs of veins, which are very prominent and result in the striking wrinkling of the leaf surface; moderately long, sharply defined apex. Occurs in Manipur, Cachar, Lushai (2).

Cohen Stuart has shown that tea is cross-fertilized and that flowers only self-fertilise with difficulty. The significance of this is that the seed from any bush may give a hybrid plant, unless care is taken to ensure that the pollen from bushes of the

(2) Tee, Camellia theifera (Griff.) Dyer, by Cohen Stuart, *Fruwirth Handbuch der landw. pflanzenzichtung.*

same variety only is available for cross-pollenization. A wasp has been noticed carrying the pollen in Java.

The need for putting seed gardens in isolated places thus becomes apparent, and the need for keeping our varieties pure is obvious. Cohen Stuart writing on tea in India says (3), "Carelessness about the variety of tea planted, carelessness about the precious wild tea tracts, carelessness about the management of seed gardens, carelessness, in short, about all measures that are liable to ensure an effective tea selection, such, I regret to say, has been the happy-go-lucky attitude of the British planters towards a matter that could not indeed, yield immediate profits, but should undoubtedly have done so at one time or another. Nor did they lack good counsel, for Sir George Watt has, ever since 1882, endeavoured to reorganise the Assam seed gardens."

How far the rebuke is merited it is difficult to say for, on Cohen Stuart's own statement, there has been hybridization in the Assam seed tracts for some time. We know too that Burma tea seed, brought from thick jungle, far removed for any modern cultivation, gives plants of widely different characteristics. It is thus probable that hybridization had been going on long before the planter came to Assam.

From the seeds of commercial jats as used in Assam and exported to other tea countries, the botanists in Java set about selecting pure strains. With this object, 22 areas in the jungle at Tjinjiroean, on the Pengalengan Plateau, each isolated from the others by a walk of at least ten minutes, were selected as sites for seed gardens. The altitude of these areas varies from 5,000 to 6,000 feet and some areas are at 6,500 feet. Each seed garden occupies an area from about 1½ to 2½ bouws (2.6 to 4.4 acres). Of the 22 areas, 19 were put out from jats imported from India and three from Java grown seed. The Indian seed includes the commercial varieties or jats known as Ghoirali (two areas), Rajghur, sometimes called Dr. Watt's variety (two

(3) "A Basis for Tea Selection," p. 206.

areas), Ghairkhatta, Mitanguri, Singlo Hill (two areas), Jaipur, Bazaloni, Itakhuli, Nakhati, Manipuri, Kalline, Alyne, Dhonjan, Kutchu, Goipani and a pseudo Itakhuli, from Itakhuli stocks with Ghoirali scions. The Java seed includes Tjiliwong, Malabar and Kiara Pajoeng.

The nurseries were planted out 15 cms. (6 ins.) square. At two years the plants were carefully selected for jat, regularity of branching, height, freedom from diseases like Brown blight and Pink disease, and were then replanted six feet apart. Four years after replanting, *i.e.*, six years from seed, a second selection was made according to jat, freedom from Corticium and root diseases. In the seventh year from seed, a third selection was made and in the eighth year still another.

By this method of stringent selection, only 250 trees were left in the 22 gardens, and these were used as parent trees in the grafting work which followed. As planting was begun in 1914, the parent trees are now 14 years old. The Ghoirali clearance showed the most parent trees with 40, and Rajghur came second with 28.

The value of the vegetative propagation of tea will be appreciated, although the possibilities are not so great as with some other crops. By means of grafts or bud grafts, a seed garden of uniform type may be obtained. In addition, by grafting, it is possible to obtain an absolutely uniform material for pruning, plucking or similar experiments (4).

The conversion of inferior bushes to high yielding ones has not been shown possible yet and, in any case, might not be practicable over large areas. Yet the possibility of extensive grafting is shown by the fact that Cinchona trees in Java are usually grafts from the stock of *Cinchona succirubra* and the scion of another species, *C. Ledgeriana*. The bark of the latter contains 7 to 10 per cent. quinine whilst that of the former only

(4) Vegetative Propagation of Tea by A. A. M. N. Keuchenius. Translated and summarized from *Mededeelingen van het Proefstation vor Thee*, No. 84.

contains 1 to 3 per cent. although the root of this species, used as the stock, develops quickly and well.

Before attempting to propagate tea vegetatively it was necessary to establish a method. In the tea seed gardens at Tjinjiroean many methods were put to the test, *viz.*, crown, cleft and splice grafting, layering, inarch and upright stem layering, and various kinds of budding and veneering. The results showed that crown grafting, budding and upright stem layering were the best, and a brief reference to each of these three methods may here be made.

Crown Grafting. The crown grafting is best made on a six or seven-year old stock, which is sawn off some inches from the ground and allowed to grow three or four strong shoots. After eighteen months or two years these shoots, which should not be less than 4 to 6 cms. (1.6 to 2.4 ins.) diameter 15 cms. (6 inches) above the stump, should be cut off squarely at the latter height. After an interval of one to three days, when the excessive bleeding has ceased, the grafting is done. Young plants, two years old in the nursery, may also be grafted by inserting the scion on the stem itself instead of on a two-year old shoot from the stubbed stem, as in other cases. Direct grafting in this manner is however less successful than the other.

The scion used in crown grafting must be a vigorous young shoot, the best ones being obtained from 7 to 12-year old trees, which, during the rainy season may yield as many as 50 to 150 scions per month. The best scions are the top shoots of the main stems. These young shoots are cut 20 to 25 cms. (8 to 10 ins.) long and the leaves cut back to 2 cms. (¾ in.) leaving the buds in the axils. They should be grafted as soon as possible, but if kept in a damp place, wrapped in moss or ferns they may be kept for two days.

The part of the shoot between the fourth and eighth leaf counting from the tip, is made use of for cutting scions.

The stage of development of the buds of the scion is of great importance. They should be at that stage when their tegment leaflets are standing quite apart whilst the top of the young

bud should be clearly visible between the expanding bracts. The accompanying plate, reproduced from the Report on Vegetative Propagation of Tea, by Keuchenius, illustrates this point.

Before fixing the graft, the top of the sawn stock is made smooth with a pruning knife. At the top of the stump a smooth portion of the bark, without dormant buds, is chosen for inserting the graft. The graft is bound to the stock by very thin strips of damp bamboo, and the mounted graft is carefully covered with wax consisting of—

Resin	...	... 10 parts
Suet	...	... 2 ,,
Paraffin wax		... 1 part

After grafting, young shoots growing from the stock must be cut away every few weeks for the first few months. The grafts should be shaded.

Budding. Budding may be done on the main stems of two to four-year old plants in nurseries or seed gardens, on the lower side branches of stumped trees or on two to four-year old shoots of stumped trees. Budding should be carried out as low as possible on the stem or branch which must be kept free from side growth for a certain distance during the year before budding.

The buds should be taken from branches four to eight inches in circumference with a good number of dormant buds. The bark of the budding wood should not be thin, and should be at least as thick as that of the stock. Only dormant buds should be made use of.

The buds are cut and grafted quickly andd accurately and then bound with calico and waxed.

Upright Stem Layering. With upright stem layering, the best results have been obtained with two year-old shoots of stumped or pruned trees. The branch to be layered is ringed and the bare cambium (growing layer of the stem) destroyed by gentle rubbing with the back of a knife. A split bamboo filled with leaf mould is placed round the cut. After about nine

Tea scions.

a. suitable buds ; *b.* buds too much developed ; *c.* stem too thin, with buds too far apart and insufficiently developed ; *d.* very fine scion with stout stem, buds in fair stage of development and near one another.

months the layering should have rooted and can then be severed from the parent tree and topped for planting out. Shading is necessary for a year after transplanting.

It was found that the best success with grafting was obtained from the Ghoirali, Kalline and Rajghur jats. Bazaloni was difficult to graft because of the thin cambium.

The seed gardens at Tjinjiroean as they now stand, consist of magnificent trees of a regularity and fineness never seen in our seed gardens in North-East India.

Yet, interesting and important as is the work of vegetative propagation, it has been noticed, by careful experiment, that there is practically no correlation between jat and crop and that Assam or Burma bushes with small leaves, usually assumed to be poor jat, may yield better than many of those of a purer jat. Accordingly, another selection scheme is now being worked out in which scions are taken from high-yielding bushes. For this purpose graftings have been made at an estate called Pondok Gedeh from good, medium and poor bushes on to stocks in alternate third rows. Any influence due to soil is thus accounted for if enough series of rows are taken. The crops will be collected from the various rows and correlation, if any, observed between the yield of the original bush and graftings derived from scions of that bush.

The Climate of Java.

The general features of the Java climate are abundant rainfall, feeble winds, high temperatures and high humidities, all factors going to make an ideal tea climate.

The Monsoon as we know it in North-East India does not occur in Java. The tea areas in North-East India back up to the Central Asiatic Plateau and, in this position, receive either the hot, moisture-laden winds from the Indian Ocean, constituting the south-west Monsoon, or the gentle spill-over of cool, dry air from the Tibetan Plateau, as it flows during the winter to the warm areas near the Equator. Although Java is subject to a change of wind as the thermal Equator moves north from

April onwards and another change from November on, as the Australian continent warms up, the breeze at all times of the year is a moist one, and the seasons are only marked by an increase or decrease in rainfall, and not by an entirely new set of conditions as is the case in North-East India.

The wind strength in Java is not great and even when the Monsoon is most steady, the direction is not constant.

In Java the sun usually rises in a clear sky, or perhaps a few stratus clouds, little more than a rising morning mist, appear in the sky. About nine o'clock small cumulus clouds appear and these increase till rain comes in the afternoon or the clouds abate and a calm tropical night follows. Such days often occur in Assam during late April and in May.

The table below shows the rainfall at Buitenzorg, 885 feet above sea level, at Soekaboemi, the centre of the tea area, situated at an altitude of 1,968 feet and at Malabar on the Pengalengan plateau, about 5,000 feet up. For purposes of comparison, the rainfall at Kandy, one of the tea centres of Ceylon, and at Tocklai which is representative of the Assam Valley, together with that of Siantar, the centre of the largest tea area in Sumatra are also given.

	Buitenzorg.	Soekaboemi.	Pengalengan Plateau.	Siantar, Sumatra.	Kandy, Ceylon.	Tocklai, Assam.
Elevation	885 ft.	1,968 ft.	5,000 ft.	1,500 ft.	1,654 ft.	290 ft.
	ins.	ins.	ins.	ins.	ins.	ins.
January ...	17·6	24·7	13 9	11.1	5·2	1·0
February ...	15·9	11·2	12·5	7·2	2·2	1.4
March ...	16·6	15·1	13·2	8·9	3·9	3·6
April ...	16·2	16·1	10·9	8·7	6·8	7·9
May ...	14·9	10 4	6 6	12·0	5·4	9·7
June ...	11·1	6·5	4 4	6·7	9·6	12·4
July ...	10·2	3·9	2·4	6·7	7·5	17·0
August ...	8·8	3·8	2·6	9·6	5·7	13·0
September ...	13·5	4 0	4·2	13·7	5 9	10 1
October ...	16·7	9·1	7·7	16·7	11·8	4·5
November ...	15 6	13 8	10·7	8·8	10·6	0·9
December ...	14·6	16·4	13·3	9·8	9·1	0·4
TOTAL ...	171·7	135·0	102·4	119 6	83·8	81·8

Conditions at Tocklai are indicative of those in Northern India where the rainfall shows a regular increase and decrease with the advance and retreat of the south-west Monsoon. At Kandy, the advance of the south-west Monsoon is apparent somewhat earlier than in the Northern India. The heavy rainfall in October, November and December is brought by the north-east Monsoon which, having blown dry from Central Asia, has picked up moisture crossing the Bay of Bengal and is thus able to deposit rain on the eastern side of Ceylon. Kandy in its central position receives copious rain from both Monsoons. Conditions in Sumatra are somewhat similar to those in Ceylon.

In spite of the fact that Java, like Ceylon and Sumatra, is surrounded by sea, it actually gets only one wet season over the greater part of the island, although the dry season is only dry by comparison.

Most of the rain comes from a north-westerly direction for the west or wet Monsoon has travelled farther over the sea than the east or dry Monsoon. Also, during the wet Monsoon, the vertical factor in the air movement is an ascending one and the opposite of the east Monsoon (descending), both factors tending to accentuate the particular characteristic of the season.

In the east of Java, droughts may be severe and this is one of the factors accounting for the fact that tea is practically confined to west Java.

In North-East India, with a five-month drought period, it would appear at first sight that conditions were much harder than in Java. Conditions are, however, not comparable, for temperatures are much lower in India during the dry period than in Java where, as in Ceylon and Sumatra, a steady high average is maintained through the year, with a correspondingly rapid rate of evaporation.

The mean temperatures in January and July in Java and other tea countries are shown below.

	January °F.	July °F.
Buitenzorg ...	75	77
Bandeong ...	72	72
Pengalengan ...	62	62
Siantar (Sumatra)	71	73
Kandy (Ceylon)	73	75
Nuwara Eliya (Ceylon)	57	59
Tocklai (Assam)	60	83

Frosts occur on the Pengalengan plateau and, in the lowest basins of this undulating area, damage is done to tea when the temperature falls below 30°F. Frost is registered in July, August, September and October.

Although the crop is gathered in Java all the year round, it is not distributed evenly through the year. The heavy cropping period begins in November and continues till April, coinciding with the wet season. During the drier part of the year less crop is made.

Meteorological observations are taken very fully on Java estates where, in addition to the simpler instruments like thermometers and rain gauges, sunshine recorders and self-recording hygrometers and thermometers are also used. Some estates have anemometers installed. The observations are sent to the Meteorological Station in Batavia with the result that a very complete and comprehensive mass of data is available.

The Tea Soils of Java.

The soils of the greater part of Java consist of the weathered products of eruptive rocks, and most of the tea soils are derived from the weathering *in situ* of volcanic ash, sand and lava.

The oldest rocks, granites and shales, which make up the foundation of the island, are very little seen on the surface because they were covered up during the tertiary period with vol-

canic material. The formations of the cretaceous period are also unimportant with regard to the present state of the island. The volcanic deposits of the tertiary and later periods form the greater part of the present surface. During later geological times, the eocene and miocene periods, sandstones, conglomerates and breccias of volcanic material were formed. In the later miocene period clay, marls and limestones were formed.

Andesite and basalt, give rise to about 75 per cent. of the soils in Java, the older eruptive rocks giving rise to soils are diabase and gabbro. These are all volcanic rocks of the basic type, by virtue of the fact that they contain not more than 60 per cent. silicic acid and the balance of basic oxides of lime, magnesia, soda, iron and alumina.

These basic rocks differ from the acid rocks composing a large part of the Himalayas in that they are richer in substances giving rise to plant foods. The Himalayan rocks give rise to the Darjeeling and Dooars soils. Most of the Assam tea soils are new alluvia, consisting of as much as 90 per cent., in some cases, of insoluble matter, mainly quartz.

In order to compare the Java soils with those of North-East India, some suitable method of classification is necessary. Such a classification is admittedly difficult. Thus a classification based on geological origin will not serve in regions where the climate differs widely, for the same rock may give rise to totally different soils according to climate and the degree to which the disintegrating processes have proceeded.

Classification on a purely physical basis is scarcely more satisfactory since, as such, it may involve the grouping together of soils otherwise absolutely unrelated. Such a classification is however of practical importance and will be dealt with later.

The broadest classification is related to the mode of operation of rock disintegration and rests ultimately on a climatological basis, since the process of rock degradation is controlled by

climatic factors. The original material may differ, but the constant working of a given set of conditions tends to produce the same product. On this climatic basis, the soils of Java are classed as lateritic (5).

The process of laterisation is not completely understood but it depends on the leaching out, by alkaline waters, of the silicic acid from the weathering complex. The most favourable conditions for this occur in the humid tropics and, in extreme cases, the surface soil consists almost entirely of hydrated iron and aluminium oxides.

In Java where the temperature changes according to the altitude and the rainfall varies widely, different stages of laterisation are seen. Thus on the hot, sunny lowlands where the rainfall is so persistent that the general water movement is down through the soil, typical red laterite is formed. In the higher altitudes where temperatures are lower, the sky often cloudy and the bacterial activity of the soil accordingly slowed up, somewhat less well developed types of laterite occur.

In the high mountains of Java there is a layer of white decomposing rock under the humus soil. This layer is bleached by the humic acids as they are washed down from the upper layers, carrying with them the salts of iron and alumina to lower layers. This is the reverse process of laterisation and is similar to the disintegrating processes noticed going on in some parts of the hills bordering the Assam Valley.

In other parts of Java where conditions of intensive percolation of water through, and evaporation of water from, the soil occur alternately according to the seasonal rainfall, black and brownish soils occur. These conditions correspond generally with ours in North-East India where the process of turning brown is hastened by aeration. The general tendency in our soils is

(5) This side of the subject is fully developed by G. D. Hope—"Some Aspects of the Tea Industry in Java," I. T. A. publication, 1914.

towards laterisation, although the rate of change is much slower than in Java.

One point worthy of note is that lateritic clays are not sticky as are ordinary clays in which the fine particles are composed not of the hydrated oxides of iron and alumina, but of complexes of alumina and silica.

Leaving now the geology and classification of Java soils it is of interest to examine them from the practical point of view and to compare them, with regard to their content of plant food, with the tea soils in North-East India. The Dooars soils are comparable in richness to those in Java, but the average Assam soil is much poorer.

The best Java soils contain 1 per cent. nitrogen and the average about 0.35 per cent. The average in North-East India is about 0.1 per cent. and the best soils of the Red Bank in the Dooars may contain as much as 0.2 per cent. nitrogen. The nitrogen in the alkali soluble humus or *matière noire,* in Java is about the same, or somewhat greater, than the total nitrogen in Assam. With a nitrogen content as great as is shown in Java soils we should rarely, in India, advise the use of nitrogenous manures.

On the Pengalengan Plateau the soils show an average content of organic matter of about 10 per cent., with an average alkali soluble humus content of about 3 per cent. These values compare with the best of the Red Bank soils in the Dooars. The best Java soils show about 50 per cent. of the organic matter as *matière noire.*

The potash content of the Java soils is very high, so high that it is not a factor to be considered, and the application of potash manures has been found to give no beneficial results.

The phosphoric acid is considered poor in the tea areas in west Java, although a wide variation occurs and, on this account, an average value is robbed of its significance. In the

tea soils of North-East India the average total phosphoric acid varies from about 0.05 to 0.15 per cent. and the available is about 0.01 per cent. or less. The values in Java are generally smaller than these.

The total lime also shows a wide variation in Java as in India and may be as little as 0.1 per cent. or as great as 1 per cent. on different soils. The average value for total lime in Assam is about 0.1 per cent. and on the Red Bank in the Dooars about 0.4 per cent.

The Java tea soils are slightly acid. A soil with a pH value of 6.8 grows good tea but the bushes on such a soil are subject to the root disease, *Rosellinia arcuata*. Many Java soils show pH values circa. 5.5. The pH values of the tea soils in India vary considerably, but 5.5 is a fair average. Soils showing values of about 6 or above are generally bad for tea in North-East India.

The mechanical analyses of the Java tea soils show them to vary over an extremely wide range from the lightest of sands to very heavy clays. The very young volcanic soils are very sandy and, as a rule, contain only a small percentage of clay. The young volcanic soils have had time to weather and may be classed as fine sands or as silts, although many of them are as light as the very young volcanic soils. As the age of the soil increases, the percentage of the finer soil particles increases and the older soils, which have come from the younger ones, show clay fractions often as great as 60 or 70 per cent. The geologically old soils contain still more clay than this last type.

The Pengalengan soils resemble physically some of the volcanic soils and are silt types. The striking characteristic of these soils is their richness in organic matter.

In North-East India where soils have been partly laid down by water and partly weathered, the variation in soil types is much greater than in Java.

The table below shows the various soil types in Java with the fractions given after Mohr's method of mechanical analysis (6).

Soil Type.	Sand %.				Silt %.					Clay %.
	Very coarse.	Coarse.	Medium.	Fine.	Very fine.	Sandy.	Coarse.	Medium	Fine.	
Very young volcanic	47	24	15	1	1	2	2	3	2	2
Young volcanic ...	7	9	23	22	9	11	8	6	3	2
Pengalengan	2	4	20	24	15	16	8	5	2	4
Old soils	0	0	1	2	1	3	4	12	10	63

These values cannot be exactly converted into figures comparable with analyses made on North-East India tea soils by Hall's method. A rough comparison however may be made from the following table in which the values from the first table are indicated, as nearly as possible, according to Hall's limits for the various fractions. The figures denote percentages.

Soil Type.	Gravel.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.
Very young volcanic.....	47	37	2	2	3	4
Young volcanic	7	32	31	11	14	5
Pengalengan	2	24	39	16	13	6
Old soils	*nil*	1	3	3	16	73

First, it is necessary to remark that very few of the North-East India tea soils, except in the Dooars and on the North Bank in Assam, contain gravel. The very young and young volcanic soils resemble the Mal sands of the Dooars mechanically. The Pengalengan soils are similar to the sandy silts of the Eastern Dooars, the North Bank of Assam and to some of the soils on the Doom Dooma bank. We have no soils under tea approaching the old soils of Java in heaviness. Some of our heaviest soils

(6) Over de Theegroden van Java en Sumatra J. J. B. Deuss, *Mededeelingen van het Proefstation voor Thee*, No. 89.

occur in the Sibsagar district of Assam, and contain as much as 50 per cent. clay, of a yellow colour and sticky nature.

Planting, Pruning and Plucking.

About three quarters of the tea in Java is situated on slopes and steep hills and most of the tea is planted at altitudes above 1,000 feet. On account of the irregularity of the land and because of the type of plucking, the extensive, even sheets of tea which are a feature of North-East India are not seen. The Java tea areas resemble in appearance, those of Ceylon and South India.

The tea plant in Java seeds all the year round, but most freely in November, December and January, and gives a total seed crop about the same as in India. Most of the planting is done between the beginning of the rains and the end of February and the seed not used locally is exported to Sumatra and Ceylon.

The seeds are planted about six inches apart in nurseries and overhead shading, supported by bamboos, is advocated. At about 14 months the young plant is cut to about six inches, the soil loosened and the "stump" removed and replanted in a manner similar to that employed in Ceylon and South India. Seed is often sown at stake, shaded with Boga medeloa (*Tephrosia candida*) planted in rows to help the formation of terraces. Transplanting with a clod is seldom practised.

Tea used to be planted in rows with the bushes three feet apart, triangular to the bushes in the next row planted at a perpendicular distance of four feet from the first. It is now suggested that the rows shall be six feet apart in order to leave a space from green cropping.

In Sumatra, where opening out is at present carried on all the year round, several methods of transplanting are employed. Seed is planted at stake and, by this method 50-60 per cent. of the plants live and thrive. Two-month old plants are also used and are transplanted without earth. At this stage the seedling is still living on the cotyledons, and the shock of transplanting

is not serious. From 80-90 per cent. of such plants are successful but the drawback to this method is that selection is difficult. With somewhat older plants, "stump" planting gives 70 per cent. successes, whilst clod planting with still older plants gives 90 per cent. successes.

The pruning of tea in Java differs essentially from that in North-East India and resembles that practised in Ceylon and South India. Indeed there is a close resemblance between methods throughout the treatment of the bush and the manufacture of tea in these three areas, owing largely to similar climatic conditions.

Pruning in Java is not done so well nor so carefully as in Assam although it is usually better than that in the Dooars and the Surma Valley. When a "stump," cut at six inches in the nursery, has been transplanted about two years it is cut across at about 20 inches, a little lower in the centre than at the sides. In many cases this cutting is accompanied by centering. The bush is then pruned up, on an average every two years for the next ten years or so, *i.e.*, five times, after which it is taken down again to about 20 inches.

On some gardens a "skiff" is given to the bush in place of a light prune and, although this gives leaf temporarily, the ultimate result of such treatment is detrimental to the bush.

One of the most important factors to be considered when discussing pruning methods, is climate. Java has no dry, cold weather when the bushes stop flushing, and plucking continues steadily for two or three years before the bush is pruned. On account of the climate, old wood can be cut without much snag formation and the cuts heal over well, owing to the light plucking. It is unsafe to attempt to prune in North-East India on the lines adopted in these regions of continual rain and steady high humidity. Tea left unpruned in North-East India becomes diseased and looks very different at the end of two years from the healthy bushes seen in either Java or Ceylon. Even if our bushes were as lightly plucked as in these countries it is doubtful

whether, after the strain due to the drought, the bush would enter the second season so well equipped as a similar bush in Java. Apart from labour considerations, alternate year pruning does not pay in the plains districts of North-East India. On the healthiest of tea it is however occasionally profitable (once in three years, perhaps) to leave the bushes unpruned.

After ordinary pruning in Java, the bush is out of commission for three months more or less, according to the age of the wood cut. The first plucking is made above three leaves, the next above two leaves and then above one leaf for all successive pluckings. After heavy pruning, plucking is made at a height of about 28 inches.

By somewhat closer plucking than that described above and by plucking to the *janum* or " fish leaf " in the third year, the height of the bush can be kept down so that pruning can be put off for another year, although after such a period the plant takes longer to recover than if it had been pruned at the end of the second year.

Three leaves and a bud are plucked and smaller shoots than this are considered to be immature. The plucking period is 10 or 12 days and sometimes up to 16 days. With the leaving of a leaf at each plucking the bushes get steadily taller till at pruning time they may be seven feet high. With these high bushes the thin supple branches are bent over to be plucked.

Consistent plucking to the *janum* at a height of about 30 inches has been tried in Java but this brings on Red rust and Mosquito blight. Such close plucking in Ceylon also seriously harms the bush and, indeed, in North-East India, *janum* plucking on a six-inch growth with a top pruned bush can only be practised year after year on strong tea. Judging also by experience in our own districts it seems that coarse plucking to the *janum* is much harder on the bush than fine plucking consisting of two leaves and a bud, to the *janum*. In the Dooars and the Surma Valley where three leaves and a bud are generally taken, *janum* plucking is not practised until well on in the season.

Although the actual plucking is coarser in Java than in India, the plucking is so long, *i.e.*, always above a leaf, that the crop gathered is not as large as might be expected. On account of the high bushes and difficulty in moving amongst them, the leaf is collected in cloths and not in baskets.

Manuring and Cultivation.

The practice of using artificial fertilisers is increasing in Java, but has by no means reached the same stage as in India. Experiments show that nitrogenous and phosphatic manures improve the crop but potash does little in this respect. This corresponds with our experience of manuring red soils in North-East India and is the same as has been osberved in Ceylon. Although nitrogenous manures alone give a crop increase, they are best added with phosphatic manures.

Manures are applied at rates given as so much per bush, and the following suggestions are made by the Theeproefstation. Per bush, 10 gms. sulphate of ammonia, with or without superphosphate or 20-30 gms. urea or 75-100 gms. whale fish guano or 75-100 gms. animal meal. These manures are added every other year.

The amount of manure added by 30 gms. sulphate of ammonia per bush according to Java planting, where about 3,400 bushes go to the acre, works out to 220 lbs. per acre or an equivalent of about 45 lbs. of nitrogen. The double dose adds, of course, 90 lbs. nitrogen. These figures may be compared with the practice in North-East India of adding about 30 lbs. nitrogen each year.

The manures are broadcast with a hand fork, preferably a short time before the rains or after pruning. If chemicals are given one time, oilcake may be given the next. The general idea in manuring is first to get a good, humus-rich soil, producing a good bush, which is then manured, since it pays best to manure good tea. It is suggested that poor tea should be rested under *Albizzia moluccana* (Ceylon Sau) in order to strengthen it, in preference to being manured and plucked.

Cattle manure is not used to any extent and, indeed, in a country where an effort is made to control weed growth, the use of this manure introduces a serious difficulty, because it carries with it the seed of weeds.

Green manuring by means of ground crops and shade trees is widely practised in Java tea gardens, and it is common for the whole garden to be under a green crop of some kind. The older the garden and the closer the tea the more necessary is it to supply the organic matter from shade trees.

It has been observed that different green crops are able to tolerate different ranges of soil acidity and the continued application of sulphate of ammonia seriously affects the growth of some of the crops, since this manure tends to increase soil acidity.

Of shade trees grown, *Albizzia moluccana* is the best and most popular. The Dadap (*Erythrina indica*) and *Derris robusta* are also common. Shade trees are closely planted, pollarded at about 12 feet, and later on lopped and the loppings left as a mulch or buried. It is common to leave the shade up in the dry season and to lop it in the rains.

Of the ground green crops, *Tephrosia candida* (Boga medeloa), *Crotalaria usaramoensis, C. anagyroides, Indigofera endecaphylla, Calopogonium mucunoides, Vigna oligosperma, V. hosea* and *Leucaena glauca* are at present most used. The last which has deep roots, is much grown on hill slopes. *Clitoria cajanifolia*, once very popular, is not widely used now.

The method of using green crops in Java is quite different from that in North-East India on account of the different climate. In the latter country one of our problems in the dry months is the conservation of soil moisture and a clean soil, mulched by hoeing, is necessary to that end. In Java the green crop is left up as long as possible and then cut, and allowed to grow again. The cut crop is left on the soil as a mulch to keep off the sun.

Some years ago the tea estates in Java practised clean weeding, as is still the procedure in Ceylon. This process has now been stopped and either selective weeding is used, or the soil

is covered with a low growing crop if the bushes themselves are not big enough to keep the weeds in some sort of control.

At present the consensus of opinion is against frequent soil disturbance, much as is the trend of ideas in North-East India, although control of weeds is necessary. Deep cultivation in the form of deep hoeing and trenching has also ceased to be as necessary as it was when frequent light hoeing was the rule. Another reason why the amount of trenching is limited is that it leads to the spread of *Diplodia* and prunings are left in lines but not usually buried. *Diplodia* (known as *Thyridaria tarda* in North-East India) is controlled by the addition of lime to the trenches.

Drains are not as a rule necessary in Java because the soil is so porous. The loss of soil by wash is reduced in areas where the tea is small, by means of silt pits, although after weeds have been grown selectively this practice is not continued. Soil wash is also reduced by hedges of green crops.

The hill slopes on tea estates are perfectly terraced, for the natives themselves are masters of this practice in their own cultivation. Sometimes the hill side is contour planted with a green crop before planting, so that the terraces form naturally.

Pests and Blights.

Most of the fungi which attack tea in North-East India are konwn in Java, although they operate with different degrees of virulence.

Of the root diseases, *Ustulina zonata* (Charcoal stump rot) is common on all soils. *Rosellinia arcuata* (Black root rot) occurs on soils which are neutral or only faintly acid. *Fomes lamaoensis* (Brown root rot) occurs sometimes, but *Sphaerostilbe repens* (Violet root rot) does not attack tea, although it is common on rubber and green crops. *Diplodia* (Die back) also occurs.

So far as leaf and stem diseases are concerned, these blights are much less prevalent than in North-East India, where, at the

end of the season, the leaves and small shoots are often a mass of blights, especially if the plucking has been hard. In Java, Brown blight and Grey blight are common but Blister blight and Copper blight are not known. Thread blights, Nectria and Corticium are known, but are not common. Red rust is a very serious blight and often completely cripples weak or debilitated tea, especially after an attack of Mosquito blight.

Septobasidium rubiginosum is very serious and may kill out strong plants, both tea and green crops. *Septobasidium* spp. are found in North-East India, parasitic on scale insects but, so far, on only two occasions has the fungus been observed to be parasitic on the tea plant. The attack of *septobasidium* in Java has increased during the past few years and has spread from dadap and *Crotolaria anagyroides*. An attack by this fungus may be followed by Red rust.

The spraying of tea for blights is not practised in Java and the formation of the land is all against the carrying of materials for intensive spraying. For the most serious leaf and stem disease, *i.e.*, Red rust, the bush is given a rest from plucking. Generous treatment is regarded as the best safeguard against fungus attack.

The most serious tea pest in Java is *Helopeltis* (the tea mosquito). The Pink mite is sometimes serious but Red spider is not so common as in India. Thrips and other pests occur, but are not serious. Green fly is not known.

Much interesting and useful work has been done on mosquito blight in Java. The species of *Helopeltis* known in Java are *H. Antonii* Sign., *H. Theivora* Waterh., *H. Cuneatus* Dist. and *H. Cinchonae* Mann. *H. Theivora*, the species doing damage in North-East India, is practically harmless in Java where *H. Antonii* takes the greatest toll of the tea bush. At altitudes above 4,000 feet a different variety of *H. Antonii* is found which prefers Cinchona to tea. *H. Cinchonae* has been shown to attack tea.

According to observations it appears that the mosquito punctures the veins of the leaf and that immune bushes are harder in the veins than others.

The mosquito cannot stand exposure to bright sunlight while dense shade encourages the pest. However, since the foliage of the bush itself provides sufficient shade for the insect, the cutting down of shade trees has not been practised in Java. The removal of shade may, however, have an indirect influence on the mosquito, in that bushes growing in the sun have a somewhat different composition from those growing in the shade. It has been observed in Assam that the removal of shade trees does, at times, diminish the intensity of mosquito attack.

Many methods of combating mosquito have been tried, including hard plucking, special pruning, hand catching, fumigation and spraying, with varying results, generally failure.

A few years ago the entomologist at the Theeproefstation discovered a parasite of the tea mosquito, *Euphorus helopeltidis*. The eggs of the parasite are laid on the first larval stage of the mosquito and, later, the cocoon of the parasite goes to the soil. When the mosquito is hand caught, samples are sent to the Theeproefstation for examination and if more than 50 per cent. of those in the larval stage are infected with the parasite, it is advised that hand catching be stopped. By this means the reproduction of the parasite is encouraged. It has been observed that shade encourages the parasite. A parasite of *Euphorus helopeltidis* has also been discovered but it is rare. In North-East India a parasitic mermithid worm has also been observed but its ravages on the tea mosquito are not serious enough to warrant any hope that it may control the pest.

On Tjiboengoer Tea Estate interesting experiments on the control of mosquito by pruning have been made (7). Briefly, the treatment consists in pruning alternate rows of tea in a block

(7) A full description of this work together with a comprehensive account of the work on tea mosquito in Java is given by H. Ashplant in "Report on Mosquito Blight (Helopeltis) of Tea in Java."

every two years. Only good areas of sound tea, from which the worst effects of the blight have been eliminated by previous good treatment, may be expected to respond to alternate row pruning.

This type of pruning has been tried on other estates, sometimes with success and sometimes failure. The reason why bushes pruned in this manner should be able to throw off the blight has not been explained, but it may be due partly to the fact that the surroundings are rendered less favourable to the insect, and partly to the fact that the area as a whole benefits by having part of the bushes exposed every year to the sunlight at pruning time.

Mosquito in Java attacks at any time, but generally in February and March, at the end of the wet season. The attack is aggravated by Red rust which often completely wrecks the frame of bush just as the subsequent attack of Brown blight in India often finishes off the devastation started by the mosquito. In Java it is observed that the weaker bushes have the axillary as well as the terminal buds attacked by mosquito.

So far as the writer's observations were concerned, the ravages of the pest in Java are not so serious as those experienced either in the Dooars or the Surma Valley. True, the crop in Java may fall to *nil* when the attack develops,, just as it does in North-East India, but the bushes with their full healthy foliage do not seem so badly hit as those in India where the plucking is harder. Hard plucking has proved fatal in Java and the best general treatment for tea liable to mosquito attack is generous manuring and light plucking.

TEA MANUFACTURE.

Power and Machinery.

The tea factories in Java are run largely on hydro-electric power, and the hilly nature of the country and steady water supply are made use of to the fullest extent in this direction. In one or two cases tea is dried by air electrically heated.

Pangledjar Tea Factory, near Bandeong, Java.
Built entirely of reinforced concrete.

The tea machinery used, like rollers and dryers, is British, as are most of the sorting machines. Individual machines are generally worked by separate motors and the absence of shafting and belting is a great advantage.

Withering

In Java, leaf is withered in lofts into which hot air passes after being bulked in a central chamber. The loft and fan arrangement is similar to that in Ceylon. Wire racks are usually employed.

The spreading of the leaf is much thicker in Java than in either Ceylon or India. Thus the Experimental Station at Buitenzorg advises that one kilo of leaf be spread on a square metre, when the racks are of wire mesh. This is about 2¼ lbs. leaf to 10 square feet, just about twice the thickness suggested in India. On boards or hessian, about half a kilo and on plaited bamboo, three-quarters of a kilo of leaf per square metre is suggested.

In Java, as in India, the value of withering the leaf at low temperatures is recognised and 82°F. is the ideal suggested for the loft. A withering period of about 18 hours is advised and a loft well ventilated with fresh air.

The leaf is considered to be physically withered when it has lost from 10 to 40 per cent. of its original weight according to the initial moisture content of the leaf. Thus it is advised that leaf containing 80 per cent. moisture when it is plucked should dry till it has lost 40 per cent. of its weight. On an average, 100 lbs. of leaf are dried to about 60-65 lbs.

In India, during the Monsoon, when the leaf on the bush contains about 77 per cent. moisture and the air temperature averages 83°F., it is customary to dry 100 lbs. leaf to about 70 lbs. At the beginning and end of the season, although the fresh leaf is drier, the temperature is lower, and a fuller physical wither is given. In Ceylon 100 lbs. leaf are dried to about 55 lbs. in the " high-grown " districts where temperatures are low.

The great difference in the degree of the physical wither in the three countries is due largely to the difference in tempera-

ture, this factor being a controlling one in determining the rate of the chemical wither. In many of the low lying Java estates, temperatures are only slightly lower than those of Assam, registered during the Monsoon. However the leaf, grown under thick shade, is said to contain a greater moisture percentage than that found in India and this factor necessitates a fuller physical wither than is customary in India.

In the factories on the Pengalengan plateau, at an altitude of about 5,000 feet, withering machines invented by Mr. Bosscha, of Malabar Tea Estate, are used. The machine consists essentially of an octagonal cage about 10 feet long, each side of the octagon being about 20 inches long, with a central arrangement for blowing in hot air.

Leaf, after being physically well withered on the racks, is placed in the withering machine, one face of which acts as a door. Enough to serve one roller constitutes a charge and the leaf is then submitted to a hot air blast at about 120°F. for about 30 minutes, whilst the machine rotates at about 35 revolutions per minute. At the end of half an hour the door of the machine is opened and, as the machine continues to revolve, the leaf is flung far out and thus cooled. The leaf loses 3 to 4 per cent. moisture during the process, becomes limp and takes on a reddish brown colour and a strong smell of apples.

It is claimed that these machines make the wither regular and reduce the time of fermentation from six or seven hours to two or three hours.

Only one Bosscha Withering Machine is in use in North-East India, in a garden in the Surma Valley. Here it has been found that the best results are obtained when the machine makes about 15 revolutions per minute and, by its use, the fermentation time is reduced from three hours to three-quarters of an hour. It has been noticed that the amount of red stalk in teas thus treated is less than with untreated leaf.

It will be understood that the Bosscha Machine deals with the chemical rather than physical processes of withering.

Rolling.

In Java, the rollers revolve slowly, making only about 40-50 revolutions per minute. The second roll is sometimes carried out in rollers revolving somewhat faster than in the first roll, the idea being that slow rolling preserves the "tip."

The rolling period, on the average, is not nearly so long as in Ceylon, where it may last three hours for the fine leaf, nor is the leaf submitted to so many revolutions as in India where the rollers make 60 or even 70 revolutions per minute.

Fermentation.

In most fermenting rooms some modern form of humidification is used. Most of the humidifiers are of the scent-spray, in which cooling and humidification of the air are carried on at the same time. A relative humidity of 95 per cent. is aimed at, since higher values than this result in deposition of moisture if a fall of temperature occurs. The need for a plentiful supply of fresh air in the fermenting room is recognised.

Leaf is thinly spread for fermentation and in the gardens of high elevation and low temperatures the fermenting room is sometimes warmed.

Firing.

Firing is usually carried out in one process in about 15-20 minutes, at temperatures varying from 175°F. to 212°F. although the lower temperatures are preferred.

Wood and, in a few cases, oil are used for firing. At Malabar Estate the firing is done electrically, and it was found that, during the earlier trials, the power consumed by a large E. C. P. machine was as much as 160 kilowatts. After the stove of the dryer had been rebuilt and the leaks in the body of the machine stopped to avoid all unnecessary air loss, the required power was then reduced to about 110 kilowatts.

In Java the firing machines are lagged or insulated by plates of itanit, eboloiet or makinit, leaving about a foot of air round the stove and the air ducts. These insulating materials are of the patent asbestos-compound type, the first kind being a thin

sheet and the other two thicker, and able to stand more rough useage. The insulating sheets are built on light iron frames in a manner which makes it easy to remove them for cleaning or examining the machine.

By insulation, the fuel consumption for firing has been reduced by as much as 40 per cent. on many gardens. Taking a conservative estimate of the economy at 25 per cent. of the fuel consumption, the annual saving in North-East India would be about Rs. 10 lakhs reckoning on a crop of 320 millions, and assuming that it takes one maund of coal costing one rupee to fire a maund of tea. The cost of insulation is about half the saving in fuel cost during one year.

All stoking of the dryers is done outside the factory and this precaution against dust and untidiness, is in keeping wih the general cleanliness of the Dutch tea factories.

Sorting.

The sorting rooms are kept scrupulously clean and free from dust. Above each sorting machine are air ducts which remove fluff and keep the atmosphere clear. The result of this is that the Java teas are generally cleaner than India teas, a necessity to teas selling largely on appearance.

Most of the sorters used in India are seen in Java. One interesting sorting machine is made by the firm of Assendelft de Coningh of Soekaboemi, combining the rotary sieve for broken grades and the reciprocating sieve for leaf grades, of which Java makes a big percentage.

Java teas are packed containing 7-8 per cent. moisture. This percentage, as the result of many experiments, is considered to be the best. A somewhat lower figure, *viz.*, 6 per cent., is aimed at in India. This percentage is considered to be a safe one if teas are to be kept for any length of time without risk of "going off."

On some Java estates, the moisture is estimated by means of a simple apparatus whereby a weighed amount of tea is warm-

ed with xylol. This substance distils together with moisture from the tea, and both are condensed into a small measuring cylinder in which the amount of water, sinking to the bottom as a separate layer, is read off. The estimation is somewhat simpler than that employed on gardens in Assam since it involves only one weighment.

General.

The tea factories in Java are finer than those in India so far as arrangement and order are concerned. The freedom from dust in the sorting room and the general cleanliness in the firing and rolling rooms are matters for remark. The methods employed in manufacture resemble those of Ceylon, so far as fullness of wither, slow rolling and firing by a single process are concerned.

Java Teas.

Java teas are well made and clean, and the leaf is black with plenty of twist as opposed to the greyish or brownish flaky teas of North-East India. The grades are similar to those in India although as much as 60 per cent. B. O. P. may be made.

Java teas lack flavour and the liquors are coloury but soft, lacking in strength. There is little "tip." The quality period in Java is from mid June to mid October, the dry season, when a little flavour is noticed. For the rest of the year the teas are common and plain. Even the high grown trees show little flavour although they are brighter and brisker than the low grown. The poorest months are from November to April, the wet period.

The Java tea prices are lower than those of India and Ceylon and it is instructive to consider some of the reasons accounting for this differences.

First, the climate is against true quality periods such as we get in India, for there is no season comparable with the cool, dry spring and autumn experienced in North-East India when leaf grows slowly and a good natural wither is obtainable.

The method of plucking in Java is not conducive to quality for, in addition to the leaf being coarse, the plucking is long.

In Assam it is found that, for quality, the leaf must be plucked not only fine but also close, and our best teas come from places where the plucking is to the *janum* or " fish leaf."

The manufacture of *kampong blad* (village leaf) also lowers the average quality of Java tea. In the Kandy area of Ceylon, the quality of the tea is similarly reduced by the manufacture of village leaf. On some gardens *kampong blad* is so coarse that it is rolled lightly for a few minutes and then sifted in a coarse rotary sieve to remove the very big, hard leaves. All the rough tea fibre and much of the stalk is sold as Bohea and the amount of this grade may be as much as 10 per cent. but usually varies between 3 and 6 per cent.

In addition to the influence of the leaf on the quality of the tea, there is also that of the method of manufacture. Java leaf does, from North-East India standards, appear to be chemically overwithered. The result of this, is a tea with a soft liquor.

It is usual in Java for tea planters to say that quality is not *in* the soil or the district, just as planters do in the poor quality districts in India. So far as North-East India is concerned, it has been shown that good teas, above the average price, can be made in any district and on any soil provided the plucking is close, fine and regular, but whether it is sound to make good teas by this means at the expense of crop and labour is an economic and not a scientific question.

VEGETABLE PARASITES OF THE TEA PLANT.—(*continued.*)

BY

A. C. TUNSTALL.

Blights on the Stem

In recent years considerable progress has been made in the investigation of diseases of the tea stem.

These diseases may be divided into two groups :—

1. Those which are apparently the direct result of infection by vegetable parasites.

2. Those in which the vegetable parasite is secondary to other causes.

Messrs. Watt and Mann describe four diseases belonging to the first group, namely, Thread blight, Canker, Horse hair blight and Darjeeling Stem blight. The only other stem disease, Red Rust, they describe belongs to the second group. In the following pages the diseases belonging to the first group will be described individually. Those belonging to the second group will be divided into two sub-divisions :—

1. Diseases due to general debility.

2. Diseases due to special conditions.

The practical treatment of the diseases belonging to each of these sub-divisions will be described generally.

STERILE MYCELIUM.

Thread blight; Wither blight.

Refs :—Watt and Mann, "The Pests and Blights of the Tea Plant," 2nd ed., p. 392.
Butler, "Fungi and Disease in Plants," p. 456.
Petch, "Diseases of the Tea Bush," p. 73.
Indian Tea Association, "Notes on the Spraying of Tea," Revised Edition, 1925, p. 29.

Found in all tea districts.

History.—This disease was first reported in 1868. The spore form of this disease has never been found on tea and it is therefore impossible to give it a scientific name. The name given by Watt and Mann *Stilbum nanum*, refers to another fungus which is frequently found as a saprophyte, sometimes alone or in association with other fungi. Thread blight occurs on Coffee in Java and jungle plants in Ceylon. In India it is also found on plants other than tea, *e.g.* bamboo, the *Utengah* of Assam (*Dillenia Indica*), the Mango and Daranta, many palms and other jungle plants.

Description.—The fungus develops white strands of mycelium like threads from which the fungus receives its name. These threads grow along the branches and spread out to form a white felt on the under surface of the leaves. The diseased leaf turns brown after some time and usually dies. It remains attached to the bush by the fungal threads. All the leaves on a bush may be killed ultimately. The threads and the films of the fungus can be peeled off from the stems and leaves when wet without difficulty.

Apparently the fungus does not produce spores but is probably propagated by dead infected leaves and twigs, blown about by the wind. It thrives best in damp shady places and may be found throughout the year on old unpruned stems. Watt and Mann observe that "The fungus itself in the ordinary thread like form in the woody parts of the bush, consists in a number of very thin strands which are attached to and draw their nutriment from the stem. Wherever they go there is an internal mycelium just under the bark and the branches are ultimately killed by the choking of the vessels in the exterior of the "Cambium zone" (that is just under the bark) by the "mycelium of the fungus." The fungus has not been observed to penetrate the leaf tissues but mycelium was found in the external tissues of the old stems just outside the cork layer and especially in the original mechanical tissue outside the phloem element which is dead and functionless. The writer has not observed the mycelium of this fungus in the living cells under-

neath this layer (cork layer). But Petch says "Hyphae from the cord penetrate into the stem, and though they do not appear to injure the tea stem, open wounds or cankers are formed on the stems of jungle shrubs. Young stems are killed by this Thread blight." Butler adds "On the petiole and green part of the stem, the strands are . . . . entirely superficial. Lower down, however, the fungus enters the tissues of the stem. This commences sometimes immediately after cork formation begins. The outer cells of the cortex, external to the cork cells dry up and are readily penetrated by the hyphae. Branches pass down through the cork layer which is not continuous when first formed and accumulate in the cortex below the young cork. The result is the gradual destruction of all the tissues external to the hyphae. The outer bark splits in longitudinal strips which at first gape then roll up and separate off. New cork is formed deeper in and the process is repeated until the bark is often entirely destroyed and the wood exposed. The hyphae have been traced as far as in the cambium."

The fungus is characterised by the presence of special bodies known as anchor cells on the thread. The central portion of these cells may be oval or spherical; but portions of the cell wall project giving the cell an anchor-like appearance. The presence of appressorial layer is also a conspicuous feature of this blight. In this respect it resembles Black rot (see below). Thread blight most probably belongs to the same class of fungi, the Basidiomycetes, to which the fungus which causes Black rot belongs.

There are a number of fungi which have the same general appearance as Thread blight but these are not parasitic and differ from the above in not having the anchor cells which are found in the parasitic species.

Depredations.—This is one of the commonest diseases of the tea stem. With improvements in pruning this disease has ceased to be a serious menace to the industry. It is however very prevalent during the rainy season on most gardens

of Cachar and Sylhet especially in narrow shaded bheels between teelas.

Remedies.—The fungus thrives best in damp shady places. If the shade is reduced and the infected stems exposed to light and air the disease usually disappears of its own accord but sometimes it is necessary to either prune out the infected stems or spray with Lime sulphur solution immediately after the usual pruning. It has almost disappeared from districts where stick pruning is generally adopted.

The most satisfactory treatment of bushes attacked by Thread blight is as follows :—

1. Improve drainage.
2. Remove excessive shade.
3. Clean prune.
4. Burn prunings.
5. Spray with Lime sulphur solution (see I. T. A. Quarterly Journal, Part IV, 1926), immediately after pruning.

Corticium Spp.

Refs :—Butler, "Fungi and Disease in Plants," p. 429.
Petch, "Diseases of the Tea Bush," p. 66.
Indian Tea Association, "Quarterly Journal," 1917, Part III, p. 80; 1918, Part III, p. 70; 1923, Part III, p. 86 and 1925, Part II, p. 53.

Corticium invisum, Petch.

Black Rot.

Found in all districts.

History.—The disease was not recognised in North-East India before 1914 when it was found on a garden in Cachar. It is however probable that the disease described by Messrs. Watt and Mann as "epidemic Grey blight" was identical. The first serious outbreak was observed in Assam in 1918. It is now very

widely distributed. In some districts few gardens are entirely free of it. It was at first assumed to be caused by the fungus that causes a similar disease in Java and Ceylon. This fungus was described by Dr. Bernard as *Hypochnus Theae*, the name was later changed *to Corticium Theae*. It was found however that the fungus causing the disease in North-East India differed in some important details from *Corticium Theae*, Bern., and more closely resembled *Corticium invisum*, Petch, which is found in Ceylon.

Description.—The disease known as Black rot in North-East India is very like Thread blight. It causes irregular brown patches on the leaves similar to those produced by Thread blight but no threads are visible to the naked eye. When the weather is wet the diseased leaves are often black and the younger ones become rotten and slimy. The diseased leaves do not fall off but remain attached to the stems and to each other at points of contact by a small cushion of fungus mycelium. Occasionally they may be found hanging by a tiny thread or two like those of a spider's web. The spots on the leaves are at first small, enlarging later to large, brown or chocolate-brown patches resembling those caused by Brown and Grey blights. On light coloured thin leaves the spots are frequently light in colour with a dark margin.

The fungus mycelium is wholly external and confined to the green portions of the plant. Under ordinary conditions it is invisible but if a diseased shoot be kept in a moist chamber for a few days the fungus may grow sufficiently to be visible as a white or cream-coloured weft on the surface of the leaves, forming a cobwebby mass in the axils. The mycelium is many septate and much branched, at first colourless, becoming cream-coloured with age. The disease spreads much more rapidly than Thread blight as it produces spores freely in the rainy season.

The fructifications arise on the under surface of apparently healthy leaves. They appear as powdery white patches. The

patches are usually inconspicuous and in this respect appear to differ from those produced by *Corticium invisum*, Petch, in Ceylon. The spores are borne on short sterigmata arising from short club-shaped basidia. As a rule there are four spores on each basidium. One or more basidia arise at the end of a single hypha. The spores are ob-ovoid slightly curved on one side near the base. The size of the spores appears to vary considerably.

Depredations.—The loss caused by the disease is not at first apparent as a healthy tea bush is able to lose a lot of leaf without serious effects. The damage to the leaves often stimulates the production of new leaves and the bush may actually yield more crop for a short time. In time, however, even the most vigorous bushes suffer and go back seriously. Where the bushes are already in poor condition the loss is more quickly apparent. On some gardens very serious loss has been caused by this disease and it is obviously desirable to take steps to keep it in check wherever it is found.

Corticium Theae, Bern.

Specimens of tea shoots bearing the mycelium resembling the description of *Corticium Theae*, Bern., have been observed from time to time in North-East India but so far no fructifications have been found.

Corticium Sp. 1.

Found in all districts.

History.—During 1923 and 1924 a new disease has appeared mostly on gardens bordering the Hymalayas. This is caused by another species of *Corticium* somewhat resembling that which causes Pink Disease of rubber, *Corticium salmonicolor* B. and Br.; but differing in some details. For instance: the spores differ from those of *Corticium salmonicolor* B. and Br.

Description.—The fungus attacks the brown bark of the young wood, bleaching it. The dead strips of bark on the outside of this wood are usually unattacked and in consequence

retain their normal colour emphasizing the whiteness of the bleached areas beneath. The fungus usually starts at forks on the young woody stems and spreads thence until the whole of the brown bark is bleached, it then sometimes extends to the bark of the older stems but so far has not been found on the green shoots. On account of the whitening of the bark produced by this fungus the name *Corticium dealbans* has been suggested.

The fructifications are white or pinkish patches 1/8 inch to ¼ inch in diameter usually produced just below forks on the younger brown twigs. The basidia are long club-shaped bodies bearing two or four sterigmata at the end of which the spores are produced. The spores are oblong and colourless.

Depredations.—The fungus apparently causes little immediate damage on vigorous tea bushes but wherever conditions have been unfavourable to the tea plant it has caused serious loss. The tea at Tocklai was infected accidentally from specimens received from the Terai. In the course of a few weeks the whole area was infected, not a single bush escaped. The fungus fruited freely within two months and ample material was readily available for study. In spite of this general infection the tea remained vigorous. After pruning, the prunings were burned and some time later the whole area was sprayed thoroughly with Lime sulphur solution with the exception of a small area treated with Burgundy mixture Both fungicides were effective and the disease disappeared from all the bushes with the exception of about half a dozen. These have been left untreated for a year so that the further progress of the disease may be observed on them. Although these bushes were distinctly behind the others and a few of the weaker stems have died back they were far from becoming moribund. By the end of the year many of the remaining bushes were reinfected. Thorough spraying with Lime sulphur solution after pruning has now eradicated the fungus.

Corticium Sp. 2.

During the investigation of *Corticium Sp. 1* another *Corticium* was frequently found on dead twigs on the same bushes.

This *Corticium* forms fructifications somewhat larger in area than those of the parasitic species. They are white patches bearing basidia twice as long as those of *Corticium Sp. 1.* The spores are the same but twice as broad. It is obviously quite a distinct species. It appears to be purely saprophytic.

Other species of Corticium.

Besides the abovementioned species there is another species in Cachar and Sylhet. This species kills patches of bark, causing cankerous growths. So far no satisfactory fructifications have been obtained but from other characteristics it is probably Pink Disease, *Corticium salmonicolor* B. & Br. It is not very common.

Remedies.—The treatment of *Corticium Spp* :—The species of *Corticium* which is doing the most damage is undoubtedly that which produces Black rot. This species is fortunately wholly external and one thorough application of Lime sulphur solution is sufficient to kill it right out. Unfortunately it is impossible to spray large areas quickly and if the disease becomes general it is impossible to do much until the tea is pruned in the cold weather. If however the disease is recognised while it is still confined to small areas it is a comparatively simple matter to eradicate it. The first thing to do is to isolate the areas, because coolies, cattle, etc., in pushing their way through the tea, rub off small pieces of mycelium, to say nothing of spores, and carry them to uninfected areas. A few lines of apparently healthy bushes should be included in the isolated area. If the outbreak is on a small section it is as well to isolate and treat the whole section. Next spray the bushes thoroughly with Lime sulphur solution commencing operations on the healthy tea round the edges. In the case of a number of outbreaks occurring simultaneously treat the small scattered areas first. If there is any doubt about the thoroughness of the spraying this operation should be repeated as soon as possible. No manurial or cultural treatment is effective against this species. It is necessary to apply direct fungicidal treatment.

The other important species is the one I have referred to as *Corticium Sp. 1.* In this case the fungus is within and between the cells of the bark and to be effective it is necessary for the spray fluid to penetrate this layer. Fortunately wherever the fungus has attacked the bark the latter is rendered much more permeable and there is no doubt that the Lime sulphur solution penetrates to a sufficient extent to kill at any rate most of the fungus if the fluid be used in sufficient concentration.

The most feasible method of treating this disease is to postpone operations until after the pruning. A smaller quantity of solution is then required and further the solution may be used more concentrated. As the fungus is within the tissues and there is no evidence to show that it cannot survive for a considerable time on prunings it is desirable to burn prunings within a reasonable time of pruning. From our experience at Tocklai it would appear that one application of sufficiently strong Lime sulphur solution thoroughly well applied in the cold weather after pruning is sufficient to keep the disease in check. In addition to the special treatment described above, attention to the general health of the bushes on infected areas will be well repaid. In this connection the experience of one garden may be quoted. For some years climatic conditions have been very unfavourable on this garden and in 1924 the crop fell 50 per cent. below normal. It was then discovered that the garden was badly attacked by this disease. Owing to difficulties in water supply it was impossible to carry out any spraying operations in 1924 cold weather and under these circumstances it was decided to see what could be done by taking special care in the cultivation and pruning. Under favourable weather conditions the tea responded very satisfactorily. In spite of the fact that every bush was badly attacked by the disease the bushes looked remarkably well. It must not be assumed from the above that this disease can be kept in check without spraying but the loss due to the disease may be considerably reduced by attention to the general health of the bushes. The strength of the Lime sulphur solution sug-

gested in Quarterly Journal, Part IV, 1926, p. 161, has been found satisfactory.

Nectria Cinnabarina (*Tode*) *Fr.*

Refs.—Watt & Mann, "The Pests & Blights of the Tea Plant," 2nd ed., p. 408.

Butler, "Fungi & Disease in Plants," p. 463.

Petch, "Diseases of the Tea Bush," pp. 94 and 103.

Indian Tea Association, "Quarterly Journal," 1914, Part II, p. 52.

Indian Tea Association, Pamphlet "A Stem Disease of Tea," 1918.

Found in all tea districts.

History.—A disease attributed to [*Nectria ditissima* (?)] was described by Messrs. Watt and Mann under the heading "The Tea Canker." It has been found subsequently that the tea canker is only occasionally associated with *Nectria Sp.* Disease caused by *Nectria Sp.* however is found in all the North-East India tea districts. It is however only common in Darjeeling and the districts bordering the Hymalayas.

For many years it had been noticed in Darjeeling that the tea in the neighbourhood of certain trees, notably Utis (*Alnus nepalensis*) and Umphi (*Pyrularia edulis*), was frequently unhealthy and it was thought locally that the trees in question secreted some sort of plant poison. It was apparent that the ill-health of the bushes could not in many cases be ascribed to anything connected with the roots of the Umphi or the Utis trees as often fairly deep ditches separated the tea from the trees in question. Nor was the damage confined to the area under the shade or the drip of the trees but seemed to be determined to some extent in the case of fresh outbreaks by the direction of the wind. On some gardens it was found that *Erythrina Spp.* were centres of infection.

On investigation it was found in 1916 that the unhealthy tea was attacked by a fungus, *Nectria Cinnabarina* (Tode) Fr. For a long time however the connection between the fungus on the tea and the trees associated with its occurrence was obscure. It was eventually discovered that the same fungus attacked the flowering shoots of the trees in question.

Description.—The fungus attacks the bark of woody stems and the growing layers (between the bark and the wood) and spreads from them down the medullary rays into the pith. The wood is not at first attacked. The fungus does not kill the growing layers at once but gradually starves the infected stems which become moribund and after some months in that state frequently die. The fungus is generally present in the tissues of the plant some distance below the portion obviously diseased. On the death of the shoot, sometimes before, the fruiting stages are produced. These are easily found. They are produced on the bark of the stems. The most noticeable are pink cushions about 1/32 of an inch across which are usually produced in profusion. These are called conidiospores and consist of a mass of fungal hyphae or threads arranged together with their ends outwards. The end of each hypha swells slightly and a wall grows beneath the swelling. The swollen end then becomes detached, forming a spore. These spores are called conidiospores, and the cushions in which they are borne, conidiophores. Along with the conidiophores another form of fructification is produced —a number of dark red spherical bodies of about 1/40—1/50 inch across. These are produced singly or in groups, sometimes attached to the conidiophores, but more often separately. Examination of these with a lens shows that they have a small cone-shaped aperture. The cone-shaped portion collapses slightly in old ones. A more careful examination with a microscope reveals that these bodies are protected by hairy out-growths sometimes minutely roughened. These bodies contain a large number of sausage-shaped sacs each containing eight two-celled spores. The walls of the spores are often minutely striated.

These spores measure 10—15 by 5μ.* They are called ascospores. The sausage-shaped sacs are asci (Sing. ascus) and the spherical cases perithecia (Sing. perithecium). Still another form of spore is produced. They are long narrow ones measuring 37—67 by 3—3.5μ,* and are called fusarium spores from their shape. They are sometimes found on loose tufts of hyphae round about the perithecia and conidiophores.

The fungus was grown in pure culture from all three kinds of spores and also from mycelium found in the wood and bark of infected tea branches.

It was most successful on maize meal agar and cane sugar agar. The colour in all cases was white or pink. The conidiophores appeared in 6—8 days but the perithecia were very much later.

On sterilised tea stems the perithecia formed more quickly. Fusarium spores were produced freely in all the cultures.

Inoculations with both mycelium and conidiospores were carried out on tea bushes growing at Tocklai and were successful on wounded shoots but not on undamaged ones. From this it may be inferred that the fungus is a wound parasite. It should however be pointed out that the climate of Tocklai is so different from that of Darjeeling that it does not necessarily follow that the fungus cannot infect undamaged shoots in the latter district In any case there would be ample opportunity in all districts for the fungus to gain access to the plants, as plucking, of necessity, causes wounds and our experiments at Tocklai prove that such wounds can be infected.

Depredations.—The bushes attacked by this fungus become moribund but rarely die right out. The stems die back and the new shoots which arise lower down are generally thin and weakly. In a few cases healthy shoots break away from the collar but these quickly become moribund. The general appearance of the bushes is similar to that of tea very badly attacked by Red

* μ=1/1000 of a millimeter.

rust. In a few cases the plants form callosities on the stems in an attempt to repair the damage done by the fungus. These are not however characteristic of the particular disease as they are caused by many agencies.

The damage done by the disease was considerable, especially on some gardens where Utis trees had been planted as wind-breaks.

Remedies.—It is necessary first of all to remove trees known to harbour the fungus. This is often difficult but as the spores do not seem to travel very far it only appears to be necessary to remove these trees in the neighbourhood of the tea.

The diseased bushes should be pruned to good wood in the cold weather and sprayed with a fungicide immediately after pruning in order to protect the cuts from possible infection. The prunings should all be burned on the spot at once.

In some cases where it has been desirable to preserve Utis trees as a wind-break in the neighbourhood of the tea it has been found possible to prevent serious infection with this disease by spraying the sections in the vicinity of the trees with Lime sulphur solution immediately after pruning.

METEOROLOGICAL OBSERVATIONS IN ASSAM, 1927.

By

C. R. Harler.

The 1927 Season in Assam.

The 1927 season in Assam was, on the whole, a poor one. The early months were unfavourable because the soil was wet and cold, resulting in poor nitrate prduction. April was also a cold, wet month during which the early flush grew slowly and rim blight developed.

So far as the end of the season was concerned, September was cool and October dry, the latter owing to bad distribution, although the rainfall was above the average for this month. Both months were rather unfavourable. In November the weather improved but these conditions came too late to insure a good back end. The maximum and minimum temperatures of the latter part of the season are shown below in comparison with the average.

	September.		October.		November.		December.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
Average for past 8 seasons	88	75	84	70	79	59	73	51
Season 1927	86	72	85	68	79	57	73	48

The two seasons of recent years showing remarkably good closes were 1919 and 1924, both years exhibiting high minimum temperatures in October. In 1919 the average minimum for this month was 72°F and in 1924 it was 73°F. This factor must be regarded as an important one in determining late crops.

Further mention must be made of rim blight, the disease which attacked the bushes first in April and continued to do so with such vigour, that the plucking had to be lightened. This disease was apparent, although in a form less virulent, in both 1926 and 1925. The initial appearance followed on heavy pruning in 1925. It was noticed that the light leaved varieties suffered most whilst the dark leaved were relatively free.

The 1927 season was not a good one for wood and the pruning in the cold weather showed much die-back and many snags.

The total rainfall at Tocklai was 93.28 inches, considerably above the average, partly owing to copious falls in September which were largely responsible for the low temperatures recorded in that month.

Table showing rainfall at Tocklai, in inches.

	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Average 10 years	1·00	1·56	3·62	8·69	9·16	12·90	16·72	13·30	10·79	4·61	0·90	0·33	83·0
1927	1·40	3·44	3·85	9·78	4·64	17·12	13·85	15·66	16·90	5·87	0·74	*nil*	93·2

The feature of this table is the February rainfall which kept the soil wet and cold.

The Monsoon may be said to have ended on October 16th when a fall of 3.66 ins. of rain was recorded. This termination with a heavy fall is often the case and is probably due to the fact that the south-west moisture laden wind, instead of proceeding to the Himalayan slopes to deposit its moisture is brought to a standstill and forced to higher, colder regions by the north-east Monsoon which has commenced to blow. After these heavy falls there is generally a complete reversal of wind direction and a fall in temperature and humidity.

Sunshine.

Sunshine records are now kept at Sylee in the Dooars, and at Doom Dooma in addition to Tocklai. The records from March onwards for 1927 are as shown below.

Hours of Sunshine.

	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Tocklai	179	191	193	171	147	154	138	209	189	170
Doom Dooma	105	135	166	141	144	154	99	169	195	202
Sylee	190	217	216	144	114	149	144	223	186	142

So far as the available records go, March, April and May were sunnier months at Sylee and Tocklai than in either 1926 or 1925. No Doom Dooma records are available previous to

1927. At Sylee, in the year under review (1927), August showed 149 hours' sunshine against 127 hours in 1926 and 96 hours in 1925. August is an important month in connection with mosquito blight and long hours of sunshine at this period usually go with a light attack.

The term sunshine indicated above connotes bright light of varied intensity and composition. The importance of "light" as a biotic factor has long been recognised by all investigators of plant growth, but it is realised that the measurement of the darkened streak, left by the sun's rays on the sensitized paper used in the ordinary sunshine recorder, is a very inadequate measure of "light." The region of the spectrum which constitutes "light" from the ecological viewpoint is greater than the visible spectrum sensed by man. The larger spectrum includes the region in which the energy curve of sunlight is at a maximum, it includes the red region which assists in plant photosynthesis, it includes the blue-green region which is most effective in phototaxis (movement towards light) in plants and the ultra-violet region which produces sunburn and tanning. Both the ultra-violet and the infra-red region (that first mentioned) are invisible to man. The ultra-violet region forms part of the visible spectrum of many insects.

Certain instruments of high precision can be used for measuring, in some detail, the radiation from the sun. With a Nutting Polarization Spectrometer the following interesting observations were made.

In full sunlight the different parts of the spectrum were in the following ratio—

Orange—3,278, Green—819, Blue-Violet—131.

In the shade of a single white spruce the ratios were—

Orange—13, Green—27, Blue-Violet—38.

In a fairly dense spruce-ceder wood, the ratios were—

Orange—1.2, Green—2.7, Blue-Violet—4.0.

A series of measurements made in the open on a hazy day gave the ratio—

Red—206, Yellow—365, Green—3,278, Blue—3,278.

These data show quite clearly the blue quality of the light in shaded areas and the blue-green nature of the light on a hazy day, as compared with the red-yellow quality of direct sunlight.

These facts are of interest in connection with tea problems. Thus, in some years shaded areas are mosquito attacked and unshaded areas free or less vigorously attacked, whereas in other years the reverse holds, and a study of the nature of sunlight in different seasons would probably give interesting information.

In connection with the quality of sunlight, it is interesting to observe that, in India, our vegetable gardens suffer from the late afternoon sun and not from the early morning sun. The afternoon sun sunlight appears to contain a bigger proportion of red-yellow light than the morning sun sunlight. So far as tea is concerned, it is common experience in the Surma Valley for the western slopes of a *teela* to carry poorer tea than the eastern slopes and here, no doubt, the quality of the sunlight has some influence.

Temperatures.

The maximum and minimum air temperature, solar and terrestrial radiation and soil temperatures were taken as usual. There is nothing particular to report in these connections.

No comparative temperature figures for the Dooars have been available until recently because maxima and minima have usually been taken on bungalow verandahs. These values are not comparable with those taken under standard conditions by thermometers placed in a regulation louvred box. A thermometer box has now been installed at Sylee in the Western Dooars. Previously, the temperatures of Jalpaiguri have been taken as indicative for the Dooars, but the difference must often have been considerable seeing that this place is about 40 miles from the hills where the main tea areas are situated.

The Weather Chart for 1927.

The weather chart is drawn upon lines indentical with those of the last few years. The top curve which indicates soil mois-

ture shows the soil condition to have been much wetter during the early part of the season than during 1926.

The monthly average soil moisture for 1926 and 1927 is shown below. The soil condition in January and February largely accounted for the poor start. At Borbhetta during March, 1927 the soil nitrates seldom rose above three parts per million, against about ten parts in the average year. This difference is accounted for by the cold, wet state of the soil.

Soil Moisture at Tocklai.

	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1926	11%	10%	16%	14%	17%	17%	19%	19%	18%	18%	15%	13·7%
1927	15%	15%	15%	18%	18%	19%	19%	19·5%	20%	19%	16%	13·3%

The second curve on the chart denotes the average daily windage in miles. The only peculiarity here is the low value for December when the average mileage was only nine against a normal value of 16.

The crop curve is that of the Tocklai clearance, an area of about 2½ acres consisting in plots of Kalline, China, Kharikatia Singlo, Betjan and Panighat jats. The curve of the total crop shows the poor early crops and the big flush which came in June, after the soil warmed up. The subsequent drop in crop is partly the wake of the first flush and partly due to the leaving of a leaf before the next flush.

The curves *A* and *B* denote the areas cut to 24 inches and 16 inches respectively. The higher cut bushes are pruned annually and hence on one year wood. The *B*-areas are cut biennially on two-year wood. The difference between the crops is not so great as would be expected largely owing to the fact that the whole area was lightly plucked the previous year. Then it was observed that light plucking lost more leaf from the unpruned (biennially pruned) area than from the annually pruned area. The unpruned tea was therefore more spared than the pruned and hence gave more than would be expected normally from tea cut on two-year-old wood.

SEASON 1927

Jan. 2 9 16 23 30 | Feb. 6 13 20 27 | Mar. 6 13 20 27 | Apr. 3 10 17 24 | May. 1 8 15 22 29 | June. 5 12 19 26 | July. 3 10 17 24 31 | Aug. 7 14 21 28 | Sept. 4 11 18 25 | Oct. 2 9 16 23 30 | Nov. 6 13 20 27 | Dec. 4 11 18 25

Soil Moisture
20 %
15 %
10 %

Soil Moisture

Daily Miles Wind
100
0

Wind

Crop
600 lbs
500 "
400 "
300 "
200 "
100 "

Crop

A-Bushes cut to 26"
B- " " " 18"
C- Total Crop

Vapour Pressure
1 inch
0·9"
0·8"
0·7"
0·6"
0·5"
0·4"
0·3"

Vapour Pressure (inches mercury)

Temperature 100°F.
90°
80°
70°
60°
50°
40°

Maximum Temperature

Minimum Temperature

Rainfall
10 ins.
8 "
6 "
4 "
2 "
0 "

Rainfall

Observations Made at Tocklai Experimental Station